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EDITORIAL.

Our Next Number.

The Editor, having been named by the British Medical Association a delegate to the Annual Session of the American Medical Association, to be held at Washington, May 16-20 will, at the same time, and place attend the Sixth Annual Congress of the Associated Anæsthetists of the United States and Canada and of the International Anæsthesia Research Society. The programme is of such an outstanding character that it has been decided to devote the entire July Number of the "British Journal of Anæsthesia" to a full report of the papers and proceedings of this great gathering of workers in anæsthesia.

FOURTH OF THE SERIES OF PIONEERS OF MODERN ANÆSTHESIA.

J. FREDERICK WILLIAM SILK, M.D.

From a CORRESPONDENT.

ALTHOUGH belonging to the generation of those who following Snow and Clover carried onward the subject of Anæsthesia, Silk did not assume any prominence in the ranks as a worker in this field until 1886. That this was so arose through the fact that not until some years after Silk undertook professional labours did he decide to adopt the rôle of anæsthetist. It is probable that he owed to this circumstance the width of his outlook and variety of his experience of anæsthesia.

The son of a Solicitor, Silk on leaving his public school entered King's College, London, as a scholar and graduated in Medicine at the University of London. He held junior hospital appointments, involving the duty of administering anæsthetics and so was able to study the chloroform method of Lister, who at that time was attached to King's College Hospital *pari passu* with the methods of Charles Moss, an ardent advocate of the A.C.E. mixture. In 1881 Silk forsook his London school and became a house officer at the Leeds General Infirmary where he remained for two years. Here he gained experience in the use of Clover's method of administering ether. At this time the surgeons of Leeds were a galaxy of brilliant men including Wheelhouse, Pridgin Teale and Jessop. Pridgin Teale was one of the most enthusiastic advocates of Clover's ether methods, even although he taught, what recent workers have shown to be a faulty system, *viz.* that ether should be given with complete exclusion of air and that the association with anæsthesia of some cyanosis arising from this is desirable and wholly free from danger.

Silk, after leaving Leeds, engaged in general practice but took the appointment of Registrar of Anæsthetics and later, Anæsthetist to the Great Northern Central Hospital. He gained further special experience by becoming attached to

the National Dental Hospital in 1887 and for a brief period acted as anæsthetist to the Hospital for Epilepsy in Queen's Square.

It was not until 1890 that Silk gave up general practice and devoted all his energies and experience to the subject of Anæsthesia.

He soon found an outlet for both energy and experience. In 1889, the authorities of Guy's Hospital, largely through the untiring enthusiasm of Mr. Newland Pedley, the dentist to the Hospital, initiated the scheme of forming a large dental department and a teaching dental school attached to it, although in close affiliation with the older foundation. A number of dental teachers were appointed and students were not slow in flocking to the new teaching centre. His manual on the "Use of Nitrous Oxide" issued in 1887 became a valuable aid to his teaching at this dental school. The requirements of this dental department called for anæsthetic facilities quite beyond the capacity of the surgical side of Guy's Hospital and Silk was requested to organise a staff of anæsthetists to cope with the work.

At this time he became attached to two other hospitals, The "Royal Free," and for a brief time, The Hospital for Epilepsy, Queen's Square.

In 1891 an additional anæsthetist to Guy's Hospital was appointed, and Dr. Silk undertook the duties involved, working under Mr. Tom Bird whom he succeeded later on.

Silk at once appreciated the necessity for giving systematic teaching in anæsthetics to the students of Guy's and instituted lectures and instructional clerkships which enabled him to carry out the scheme.

It must be remembered that at this time few of the medical teaching schools possessed a regular system of teaching in anæsthetics and many did not welcome attempts on the part of anæsthetists to form classes or give lectures on what was regarded as a *parvenu* subject. Silk's scheme was very popular at Guy's and in collaboration with some other of the more progressive spirits of the time Silk pushed for a more general scheme of instruction in anæsthetics which should include all the great medical teaching schools of the metropolis. To this end he wrote his paper (*Lancet*, 1892)

"Anæsthetics a Necessary Part of the Curriculum." Eventually, the subject of anæsthetics was admitted to the schedule of the R. C. S. and the General Medical Council recognised it as a necessary subject to be taught before the final examinations could be taken.

Dr. Silk recognising the value of meetings and discussions among fellow anæsthetists, in 1893, he, with most of the anæsthetists attached to the large hospitals of London and the Provinces formed themselves into a society—The Society of Anæsthetists. Dr. Silk was Secretary for four years and threw his energies into the Society's concerns and as a result it accomplished much valuable work. At the time when most of the London societies merged into the Royal Society of Medicine, the Society of Anæsthetists became the Section of Anæsthetics, but maintained its autonomy. In 1894 Mr. Charles Moss, who had administered anæsthetics at King's College Hospital for many years, retired, and Dr. Silk was appointed in his stead. He relinquished all other appointments and gave unstinted support both to the work of the anæsthetics department and to the medical school of King's. Silk, at the outbreak of the war undertook military duty although past the service age and in 1915 he went to Malta for a year, when a party of surgeons were despatched there to form a sick base. On his return to England he was appointed consulting anæsthetist to the W. D. and instituted an enquiry into the cause of fatalities. He was promoted to the rank of Lieut-Colonel, R.A.M.C.

Although in his work Silk did not seek the limelight yet he, in a quiet and unostentatious manner did much to advance the status and work of anæsthesia. He introduced various useful advances in the anæsthetists'armamentarium, celluloid face masks, a metal mask for use with the A.C.E. mixture and the employment of minute quantities of chloroform with the ether used in the open ether method. In 1914 Silk advocated the use of soft catheters passed through the nostril in order to ensure a patent air way.

It is difficult to appraise justly Silk's position among the earlier workers in the field of anæsthetics. It is certain, however, that those who knew him and were associated with him were impressed by his sterling worth as an anæsthetist

and recognised in him one of those who gave much valuable service in the cause of that branch of science which he espoused for his life's work. This he did, seeking rather the benefit of the commonweal than mere personal aggrandisement.

Dr. Silk's contributions to the literature of anæsthesia comprise :—

"A Manual of Nitrous Oxide Anæsthesia (Churchill) 1887."

"Modern Anæsthetics, second edition, 1919."

"Chapter on Anæsthetics in Cheyne and Burghard's Manual of Surgical Treatment."

"Chapter on anæsthetics in Rose and Carless' Surgery."

Papers, Articles etc.

Practical points in connection with Nitrous Oxide. Post Graduate Lecture, National Dental Hospital. 1888.

Anæsthetic Apnœa, a Clinical study. *Lancet.* 1889

Anæsthetics in Nasal obstruction. *Journal of Laryngology.* 1889.

One Thousand Nitrous Oxide Administrations. *Journal of Odontological Society.* 1890.

Bromide of Ethyl in Dental Surgery. *Transactions of Odontological Society.* 1891.

Further Observations on Bromide of Ethly. *Journal of British Dental Association.* 1891

Bromide of Ethyl as an Anæsthetic. *Practitioner.* 1891.

Anæsthetics, a Necessary Part of the Curiculum. *Lancet.* 1892.

True Lines of Advance in Anæsthetics. *Guy's Hospital Reports.* 1892.

Selection of an Anæsthetic. *King's College Hospital Reports.* 1893-1894.

The Uses and Misuses of Anæsthetics. *Harveian Society.* March 1st, 1894.

Administration of Gas and Ether. *Guy's Hospital Reports* 1894.

The Anæsthetic Registers. *King's Colloge Hospital Reports.* 1894-1901.

EMERGENCIES IN ANÆSTHETICS.

A Lecture delivered to Post Graduates on March 31st, at the Medical Society of London's Hall, Chandos Street,

By CHARLES T. W. HIRSCH,

Anæsthetist to the London Temperance, Samaritan, Royal Ear, West End Nerve and other Hospitals.

To-day, Gentlemen, we can contemplate the results of various investigations in that side lane of our speciality, which has been opened up by many regarding the evaluation of anæsthetic risks. This work, though perhaps still in the bud, has produced fruit, which has revolutionised the whole question of emergencies in anæsthetics. I will even go further, and suggest that it has reduced them and will eventually eliminate them altogether.

It is said that the anæsthetic branch of the profession is monotonous. Still, even to-day, thanks to human limitations and the personal equation, thrills as profound as any at the Grand Guignol Theatre, may crop up to inject a few raisins of interest into the alleged tasteless dough of our existence, by the dread that the dim spectre of sudden respiratory failure may unexpectedly stare operator and anæsthetist in the face! The Duke of Wellington said that successful generalship largely depended upon the ability to divine what was going on at the other side of the hill. The same can also well be said concerning the administration of anæsthetics. People speak of safe anæsthetics. Surely that is rather an inappropriate way of expressing it. All anæsthetics are more or less poisons. If they were not, they would not produce uncon-

sciousness. Those, however, that give a timely warning prior to becoming dangerous, are safe, subject to our being able to interpret the signs in time! What can be anticipated before it actually occurs, can always by prompt and timely action be prevented from taking place. For example, by correct preoperative evaluation and preparation, the cardiac cripple, who has had rest and digitalis, may develop sufficient cardiac reserve to resist the shock of operation and the anæsthetic. The same can be achieved in the diabetic by preliminary rest, and the administration of insulin, in the exophthalmic by rest and iodine, in the toxæmic by preliminary dosage with glucose and insulin. What is required is, that the man at the anæsthetic helm, has before him the chart of the hidden rocks which abound in the anæsthetic sea. If he possesses this, those submerged reefs may be avoided, and and by the equivalent of the lead and compass, he can steer the human bark into the harbour of safety.

Some of us may recollect having seen the picture of sudden cessation of respiration on the operating table. Breathing seems to have stopped, the pupils have dilated, the patient's colour has become ashen grey, and the blood no longer wells into the wound. Then, if earlier preventive measures have not obviated these occurences, it is the speedy application of the instant correct treatment that will or will not seal the fate of the patient. Do I now drop a brick, or probably a bombshell into the sheltered refuge of many? Still, putting aside cases suffering from hopeless types of disease, I suggest that deaths under anæsthetics are preventable. We, the producers of sleep, fighting the dim spectre of death, should not be on the losing side. By preoperative, well thought out treatment, in selecting which we may well invoke the aid of the physician, and the selection of an appropriate anæsthetic and method of administration, these harassing, undesirable thrills can be eliminated. I believe a new era has dawned in Anæsthetics. Our task to discuss is not so much the treatment of emergencies, though I hope to consider some of them, but what seems much more of value is to find a common denominator in method of preparation of the patient and in selection and administration of

the anæsthetic, so as to avoid them. This is the problem we have to tackle in our scramble among the anæsthetic alps.

The preoperative estimation of the risk is aided by various evaluation tests, of which the chief are:

1. Sabrasez's. In this, the patient while at rest holds his breath, to facilitate which the nose is compressed; an average normal case can do so for 25-30 seconds, if only for 20 seconds acidæmia is indicated, while acidosis is suggested if he cannot do so for 10 seconds.

2. Moot's Rule is to estimate the pressure ratio per cent, by placing the diastolic pressure as the denominator and the pulse pressure as the numerator. If the pressure is high or low, there is reason to apprehend danger. Anything between 25 per cent. and 75 per cent. is probably operable; outside these limits it is more than a questionable risk. A useful aphorism is: the greater the difference between the systolic and the diastolic pressure, the greater the heart load, and thus danger of heart failure.

3. The Energy Index is obtained by multiplying the sum of the diastolic and systolic pressures by the pulse rate. In referring to the result it is customary to omit the last three figures, and designate it merely by the thousands it represents. Grover, from his experience of some twenty-five year's study, states: that the normal range is from 13 to 20. When less than the former, general cardio vascular weakness is suggested; when above the latter an excessive circulary load is being carried.

4. McIntyre's Test. In bad risks the adrenalin reserve is deficient. This deficiency can be roughly estimated by setting the sphygmomanometer at the systolic pressure, and getting the patient to maintain a deep inspiration for thirty seconds, during which time the systolic pressure is observed every five seconds. In this way patients may be grouped as normal, sympathetico-tonic, or vaso-tonic, and the latter divided into three categories according to the adrenalin depletion.

5. The effect of exercise, such as jumping or running on the heart. It is important to bear in mind in this matter that the time which may elapse before the cardiac rate returns to

the former level after physical exertion is of greater significance, than the degree of increase induced by the exertion.

Of course during recent years it has become rather the fashion not to pay much attention to cardiac murmurs. As long as the valvular defect, by being a mechanical inpediment to the work of the heart muscle does not cause a change in the condition of the myocardium this is correct. It is those who live beyond the limit of the heart's strength, whose hearts are constantly tired, that are dangerous risks. These are the cases, which by a period of rest, coupled often too by the administration of digitalis, do thus develop a more normal cardiac reserve, and thus become safer risks. Those unable to tolerate digitalis are often improved in a few hours by the intravenous injection of strophanthin. In heart block too, adrenalin hydrochloride is successful. The old favourite of Don Quixote, venesection, though transcient in its effect, is advantageous, in some cases of supernormal blood pressure.

By these means frequently it is possible to perform operations, which are indicated on surgical grounds, but which otherwise it would be impossible to venture on.

6. The possibility of post operative acidosis may, of course, be presumed to be likely to occur in cases of toxæmia. Beyond the rough test first given (Sabrasez's test); there is of course, the estimation of alveolar carbon dioxide by collecting a sample by Haldane's and Priestley's method, or by Plesch's rebreathing method, and subsequent analysis over Haldane's apparatus. An ideal as well as delicate test is afforded by the increase in tolerance to sodium bicarbonate. Normally the ingestion of five grammes of sodium bicarbonate is promptly followed by its excretion, anyway in part in the urine, the reaction of which becomes alkaline. In acidosis there is a diminished alkali reserve, or total capacity of the blood plasma for combining with CO_2, thus sodium carbonate is stored in the tissues and the urine remains acid, that is, there is an increase in tolerance to sodium carbonate.

Another test which is of value is the estimation of the hepatic efficiency, certainly of use when an anæsthetic is proposed, for it is chiefly through the liver cells that the

anæsthetic is got rid of and the safely of an anæsthetic depends greatly on its rapid elimination, after the cessation of the administration. The technique consists in estimating the blood sugar before and after the taking of some fifty grams of lavulose, the amount varying with the patient's weight. If the hepatic cells function normally, an hour after the taking of lavulose, the rise in sugar should not be very great, in no case more than 0.012 per cent. and at the end of two hours, the blood sugar should be normal. Deviations from these results indicate imperfect action of the liver cells, and thus certainly would exclude chloroform as being suitable in such cases.

This brings the subject of the appropriate type of anæsthetic forward, as one of the means of avoiding emergencies.

Types of Anæsthetics.

Gas oxygen, or perhaps one of the newer gases such as ethylene or acetylene for the diabetic, a spinal of stovaine or novocaine for the aged, if the blood pressure is not too low, and combined probably with unconsciousness produced by nitrous oxide oxygen. Intratracheal ether for a cerebellar tumour, intratracheal gas oxygen and perhaps a little ether bubbling for the removal of exophthalmic goitres, colonic ether perhaps for the ordinary thyroid operation, gas oxygen for Cæsareans and ectopics. When discussing and settling the best method of administration and anæsthetic, we must guard against the use of any technique injurous, directly or remotely to the patient. The decision must be made irrespective of our natural anxiety to achieve the goodwill and compliments of the operator. Most of our colleagues, the surgeons, are sympathetic in co-operating in the selection of a suitable anæsthetic. Still, undoubtedly, the best anæsthetic in the minds of some, may not imply an ideal condition of the patient's safety or welfare either during or after the operation. I admit that naturally it is also our duty to avoid cyanosis, prevent congestion, as well as to produce such relaxation as the nature of the case makes essential for the work of the surgeon. Co-operation between operator and anæsthetist can achieve this, and my experience is that the

former are invariably most pleasant to work with, and in reason agreeable always to fall in with any suggestions which may add to the safety of the patient, and assist the labour of the anæsthetist.

We are all, I believe, unduly unsympathetic to the unorthodox. Anyway, in spite of the lurid tones in which some of my highly esteemed colleagues regard chloroform, I yield to none in my appreciation of its use, but there are reservations in my enthusiasm for it. Included in the list of unsuitable for chloroform are certainly all cases of toxæmia, for fear of subsequent acidosis. Also exophthalmic goitres and cerebellar tumours. In fact, I will go as far as to remark that if it be employed for either of the two cases just mentioned, their chances will probably rather resemble that of a snowball in hell!

In addition to the selection of the anæsthetic, the method of administration is of importance. I admit that with some administrators a piece of lint and a drop bottle of chloroform or ether will achieve excellent results. All cases cannot, of course, be so dealt with. An ideal to aim at is an induction without struggling, an unconsciousness without cyanosis, the relaxation the surgeon needs, and a recovery without sickness; all too, minus emergencies! Still, a Utopia that will be arrived at. The chief essential to this is the gradual quiet induction, followed by a uniform and regular anæsthetic depth and dose. Deanæsthetization by the administration of oxygen with 20 per cent. carbonic dioxide at the termination of the operation, by increasing breathing and thus elimination of the anæsthetic, does tend to the relief from nausea, sickness, and gastro-intestinal distension. Some form of percentage inhaler is of advantage in administering chloroform. For gas oxygen, a sight feed apparatus is essential; with a Y connection it can be employed also for acetylene or ethylene, and this likewise permits of carbonic dioxide being given. My apparatus which is made by Messrs. Coxeter, can also be employed for bubbling oxygen through or over ether, chloroform; or paraldehype. A mercury blow out permits of its use for intratracheal administrations. Emphasis was laid on an aphorism recently published in St. Bart's

Gazette :— "Take care of the air-way, and inquests will take care of themselves."

After all this preliminary chatter, which won't perhaps cook the rice, we can now descend to our real subject—

EMERGENCIES!

Our learned friends, the physicians, divide diseases into two lots—the functional and the organic. As their education and facilities for more perfect examination of the patient advance, gradually most of the first-mentioned pass into the second class. We can divide our work in a similar manner. Emergencies—(1) Preventable, (2) Unavoidable. Some day all the latter will be put in the first category.

Our theme is thus narrowed down to difficulties in inducing, during or after anæsthesia, which have at times terminated in emergencies, but should not and will not do so in the near future. We must think more of not missing once, than of hitting the mark a hundred times, though few will stoop until they have hit their heads!

We can consider our subjects under three divisions :—

1. Minor difficulties.
2. Respiratory troubles.
3. Circulatory derangements.

1. *Minor difficulties.*

My object now is to fill the mental vision with the sights, sounds and even scents of the minor difficulties. Undoubtedly it is by watching for deviation from the normal, and relieving the results, which may be trifling that difficulties, that may become dangerous, are avoided. This does not require penmanship on my part. To the enthusiast the signs and symptoms are calling every moment, our very heart is beating in unison with the patient. We are in touch with the actually on our job. Our unconscious mind is busily at work. From depths beyond fathoming old memories are stirred. All the attempts on the patient's part to seize every opportunity to escape from the trammels of the normal . . . the hesitating breathing, the slow and shallow, those that sob, cry, cough, retch or vomit. Frequently the patient will

breathe through the nostril, which may be inadequate. Instruction should be given to do so through the mouth. The habitual use of some form of mouth prop is of value, as it maintains the mouth open. Nervousness and fear may also produce restricted breathing. A quiet encouraging chat will often dissipate these apprehensions. If we can put ourselves in the client's place, think how he feels, then by a few kindly words gain his confidence, it will not prolong the period of induction, rather, by banishing all resistance on the patient's part, it will expediate matters. With children, stories, coupled with chocolate covered mouth props may often eliminate all screaming and wriggling. Of course, the great thing is to anæsthetise the little one quickly. I am sure that the psychic effect of fear during induction does account for many cases of chorea and nerves. If a prop be soaked and rubbed in powdered chocolate and sugar, with a little tact the child will bite and suck it, then, with ethyl chloride, unconsciousness can be obtained almost always without fear or dread and also minus tears. Certainly for success, a conception of the psychology of children is worthy of study. As is said of ourselves, most can be managed by administering to their stomachs!

Frequently restricted breathing is the result of too strong a vapour. The remedy is, of course, sufficiently obvious. A common cause of apnœa is through too deep breathing. As Drs. Pembry and Shipway have pointed out, deep breathing washes out too much CO_2. Respiration should be natural that is quiet and easy. Any attempt of the patient to obtain unconsciousness by deep and too rapid respiration disturbs the natural ventilation of the lungs; there is a sense of discomfort, due to the attempted establishment of the anœsthetic tension in the blood too quickly cutting down the supply of oxygen, and with chloroform there is also the risk of an overdose. Apnœa may also occur during prolonged gas oxygen administrations, if the administrator is regardless of expense, and uses the expiratory valve continuously. Rebreathing abolishes this by introducing the needed CO_2. Of course, an excess of CO_2 plus a lack of oxygen may produce apnœa, which, if not relieved, may have a most

serious effect. Falling back of the lower jaw, retraction of the tongue, Laryngeal spasm, accumulation of secretions or foreign bodies in the respiratory tract are complications which throw an undue strain upon the nervous and cardiovascular systems. Excessive secretions, which may become churned up and aerated in the larynx constitute a most serious risk, especially in cases of dilated hearts. Preanæsthetic administration of atropine will eliminate secretion and thus this danger and worry. The use of a mouth prop during induction, and after of a properly introduced air-way will do away with mechanical blockage, the result of the tongue falling back. This brings me to the tongue forceps. Most are vile implements of torture! Many, when starting anæsthetics, seem to regard the tongue forceps as a sign of their "Trade". So many prominently display them by affixing them to their jackets! If they left it at that I would not feel called upon to buckle on all the weapons of persuasion, and if I could, in addition, those of sarcasm, to urge that these lethal weapons should merely be employed to lever, when needed, the tongue forward, and not, as many do, to grip forcibly wound and bruise that innocent organ with! Pulling on the tongue with these tools of the inquisition merely stretches the anterior and front part of the tongue. It has absolutely no effect on the base, which is generally the cause of the trouble. Inserting any blunt instrument, such as a sponge fixed to a secure holder, to the base of the tongue, and thus pushing or levering it forward, will open the road of the respiratory tract and remove the impediment. As to sponge holders, many have played anæsthetists and operators falsely. The type in which the two or three holding blades are kept together by a pushed up ring frequently do not fulfil their function and retain their firm grip. It is not always convenient in the midst of an operation to get an endoscope expert and hand the case temporarily over to him. I therefore advocate Spencer Wells catch type tongue forceps with fenestrated ends. They can be depended upon.

Coughing and retching and even vomiting is apt to occur during induction in smokers. Spraying with a little cocaine and the use of a mild antiseptic gargle previously to coming

into the operating room is a preventative. In these patients gas oxygen is generally preferable to either ether or chloroform.

The avoidance of handling or interfering with movements during the semi-unconsciousness of induction generally eliminates struggling, especially if the induction is gradual and air restriction is not employed. Struggling is naturally exhausting and most undesirable, rendering the heart in many cases not as fit as it might be to withstand the strain of operation and anæsthetic. With a properly prepared case vomiting is exceptional. Intestinal obstructive vomiting may, of course, be a source of worry. In these cases, the washing out of the stomach previous to the administration may be resorted to. The danger during anæsthesia or after, prior to consciousness of vomiting and particles of the vomit entering the air passages and causing asphyxia must be remembered. Inversion will generally expel the foreign body, but if cyanosis occurs, air must of course be got into the lungs, and failing to dislodge the obstruction, an endotracheal catheter must be passed or tracheotomy performed. To ensure that the skeleton architecture of our subject may, anyway, be without flaw in the matter of completeness, reference should, I suppose, be made to that panacea for unexplained anæsthetic deaths—Status Lymphaticus. I wonder if the lamented King Herod came back to earth and this time ordered the slaughter of all the five-year-olds, whether nearly all, if post-mortemed, would not possess a large persistent thymus! Still even the head of a sardine is something if it is believed in. Perhaps it is a good fiction to be kept up, for after all, "He who rides on a tiger can never dismount." There is no telling when the popular and accepted explanation "Status Lympahticus" might be of use to any of us personally!

2. *Respiratory Troubles.*

Respiratory troubles may be due to two chief causes:

(*a*) Some mechanical interference with the action of the respiratory pump.

(*b*) A disturbance brought about by central arrest, that is interference with the respiratory centre.

These producers of grey hairs among the anæsthetic branch may now perhaps be briefly discussed.

(A) Under this category is included blocking of the upper air passage by spasm, actual swelling of the mucus lining of the air tubes, as altered position of the parts, causing a kinking of the air passages, foreign bodies including mucus, producing a blocking, or any condition precluding lung expansion, such as pressure of operator's or his assistant's hand on the chest.

(B) This division comprises all causes of failure of nerve supply to the involved parts, through interference with the respiratory centre. Three main causes may be mentioned.

1. Toxic, due to overdose of the anæsthetic, or overdose of the preoperative alkaloidal preparation, such as too much morphia or hyosine.

2. Anæmia of respiratory centre from fall of blood pressure, or actual damage to centre itself during operation, such as may occur in operations for cerebellar tumour.

3. Reflex from inhibition of the centre from stimulation, such as may be produced by surgical shock, if the patient be only partly anæsthetised when operation is started, or by rough handling of important parts, such as traction on mesentery, uterus, broad ligaments, or by orthapædic manipulations etc.

This latter division can be credited to the anæsthetist through error in giving overdose or underdose, as well as already mentioned, to the operator, through want of gentleness.

The treatment comes to this. In Class A, removal of the impediment or obstruction producing the embarrassment. Frequently pressing jaw forward from the back at the angle so as to bring the base of the tongue and epiglottis away from the pharyngeal wall is all that is required. In many cases, in this position, mechanical obstruction is thus caused, and spasm may retain the parts in that situation. In separating clenched jaws a mouth opener or wedge may be needed.

In Class B some means of artificially supplying the temporarily arrested motor force is indicated, that is artificial respiration by Sylvesters, Marshall Hall's, Schafer's or

Labord'e methods. Of course, prior to carrying out artificial respiration, the air passages must be cleared and their patency effected, the tongue being levered forward, so that this organ by position is not obstructing the breathing.

The methods of these various means of carrying out artificial respiration are sufficiently well known to obviate further reference on my part beyond the need of ensuring when aid in performing them is called in, that those taking a turn at these resuscitation exercises are not windmilling the patient's arms nor perhaps compressing the chest to such an extent that the ribs may crack. Many may recollect such undesirable incidents. In lieu of these exertions a pulmotor may be employed. It consists of a pump worked by oxygen, and a face piece, which must be fixed over the mouth so that a gas-tight joint is obtained, prior to which, naturally, all means must be carried out to effect patency of the air passages. In this matter the introduction of an air way is an advantage. The apparatus when correctly fitted, pumps oxygen into the lungs, and by suction likewise performs expiration. It can be set to do it, at any rate, and the quantity pumped in and drawn out can, within limits, be varied. If employed, it is as well to practise using it, and to make certain that the bag is without holes, face piece properly inflated, and the oxygen cylinders full. Improper use has resulted in the rupture of the alveoli of the lungs. While mentioning these just named essentials to its efficient use, the need for prompt action, I would suggest, brings out that previous drill in emergencies might, by ensuring knowledge of what each has to do, and the most expeditious way of carrying out their duties, frequently obviate a catastrophe. We have everyday fire drills, and on ships boat drills, so that everyone knows his stations when the signal is given. Might we not, likewise, have life saving drills in the operation theatre? Efficiency and life are synonymous when emergencies occur. "Kismet" should not then be the excuse. Knowledge of what to do and how to do it quickly and correctly might avoid the patient's doom.

To return to the pulmotor, its value has been enquired into in America by representatives of the American Medical

Association, the National Electric Light Association and the American Institute of Electrical Engineers. Among many experts on this Commission may be named Yandell Henderson and Dr. Crile. Their observations on animals led them to note two factors, which they deemed detracted from its seeming great value—namely, its automatic activity and the ease with which inspiration might be turned into expiration. They remarked that in normal respiration, expiration is accomplished by a power which drives the air out, by the elasticity of the distended or compressed tissues, aided also often by muscular contraction. Suction does not come into this act; but it is by suction that the pulmotor carries out expiration. When air is sucked out from the trachea the bronchioles, not being stiffened by cartilage, are liable to close before the suction reaches the alveoli, as the walls may collapse and stick together. Also when the inspiratory blast meets an obstruction in the air passages, it may be automatically cut off, and turned into expiration, and thus no air may enter or leave the bronchial tree. They rather thought that the high credit, given to the pulmotor did not have a substantial foundation. Still, if artificial respiration is carried out say by Schafer's method, there is a great advantage if oxygen, or oxygen with say a percentage of the respiratory stimulating CO_2 be likewise administered. Thanks to the kindness of Messrs. Siebe Gormon & Co., Ltd., I am able to demonstrate two contrivances for so doing .(The Novita and the Novox apparatus were then demonstrated and their value in resuscitation dwelt upon).

In respiratory failure, in addition to the value of CO_2 as a stimulant of the respiratory centre, the value of reflex stimulation, by application of heat to the skin or cold, or stretching the sphincter and putting mustard over heart area must, of course, not be omitted, also the intratrachael administration of oxygen and carbonic dioxide.

A. *Circulatory Derangements.*

Though I desire to avoid academic platitudes, I fear I should be failing in my purpose, if I omitted a list of predisposing causes of cardiac failure. These amount to any factor that leads to alteration in quantity or quality of the

blood. Loss of blood from injury, from bleeding due to blood sucking parasites, (ankylostoma duodenale) from cachexia due to disease, and occasionally such apt to be neglected matters as food in the stomach or the sitting posture, may lead to circulatory trouble.

A recognition of these producing influences, may if noticed in time, and acted upon by proper preparation of patient, as well as choice of anæsthetic, obviate any possible circulatory emergency.

The value of most articles is probably in ratio to which one's own failures, as opposed to successes are given. I therefore propose now to digress, and narrate particulars of a death I had last February.

Operation for radical cure of inguinal hernia, patient a plethoric man aged about 56. Induction Nitrous Oxide Oxygen, some struggling, bubbling over paraldehyde occasionally employed. In middle of operation, sudden occurrence of cyanosis and respiratory failure. Airway removed, found to be clear, oxygen pushed, within fifty seconds breathing and colour normal *but patient noticed to be pale*, pulse normal. Operation proceeded with. After I had left the hospital, as the patient was being lifted off the trolley, cyanosis and respiratory stoppage came on. In spite of usual remedies, artificial respiration, injection of adrenaline into heart, tracheotomy introduction of oxygen directly into windpipe etc. death ensued. P.M. showed three pulmonary emboli, one very small, which must have caused the cyanosis and pallor during operation, the other two extensive, that produced death and came on after operation, as patient was lifted. Pathologist noticed thrombus extending from seat of operation up the spermatic vein. The only lesson seems that I should have been satisfied with my conviction, that the airway was satisfactory and sought for other explanation of the temporary cyanosis. The rapidity of the return to normal, in spite of the pallor, is the only explanation. Pulmonary embolism is of course, rare, and if every time a patient became temporarily dark, the anæsthetist was to suggest Pulmonary embolism, and advise cessation of operation, he might be as unpopular,

and perhaps as dangerous, as the one who advises heart massage whenever there is circulatory failure, though only temporary.

The actual producers of heart complication are:

1. Results of overdosage anæsthetic causing inhibition or paralysis.

2. Results operation from shock, hæmorrhage or entry of air into vein or detachment of thrombus causing embolism.

3. Incidental to other causes, asphyxia due to impaired airway or actual respiratory centre paralysis.

The divisions may, perhaps, now be individually considered.

1. Observation and keeping to a regular dose and depth should generally prevent an overdose. There are always indications, but these are more easily detected with ether than with chloroform. When noted prompt action is essential.

Firstly of course, the administration must be stopped, the patient, if not in the horizonal position, brought into it, with the head lowered. To eliminate the anæsthetic, the respiratory action must be increased, CO_2, by stimulating the centre, is most valuable, and should be given with oxygen. Artificial respiration, if needful performed, and if the heart has ceased to function, direct kneading of the heart, that is, heart massage must be considered. If the peritoneal cavity is already open, the heart can be grasped through the diaphragm, otherwise an incision must be made through the epigastrium, and so direct access obtained to the pericardium. The heart should be squeezed about seventy times a minute. Artificial respiration being performed simultaneously. Mollison reports success, by such action, in a case after there had been cessation of beats for 13 minutes. Opening the abdomen for this purpose must, of course, not be lightly undertaken. Drugs are of little avail if the heart is not functioning, to send them round to stimulate the centres. Camphor in oil, pituiterin, digitaline, caffene as well as strychnine are the ones usually employed. They are probably more used for mention at the inquest, than for the actual benefit to be expected. Reed Hill reports success in a case, by injection of Min. 5 of 1 in a 1000 adrenalin solution into the heart muscle, through

the fourth left intercostal space close to the sternum. Care must be taken that the needle is not broken off and left *in situ*. This has been known to occur.

2. Cardiac failure from shock, hæmorrhage, entry of air into a vein, or detachment of a thrombus causing embolism.

The aphorism that there is greater danger in light anæsthesia than when reflex inhibition is prevented by the patient being deeply under is correct, in as far as primary shock is favoured by too light anæsthesia, though it must be borne in mind that secondary shock is favoured by deep anæsthesia, especially if chloroform be the anæsthetic. Primary shock roughly, can be assigned to vaso-motor centre disturbance, and with prompt action need not be dangerous. Secondary shock, that comes on a little time after an operation, may be a much more serious affair and may be fatal. Exhaustion of vaso-motor centres, exhaustion of suprarenal glands, and lack of the centre stimulating CO_2, have been assigned as the cause. Keith's investigations seem to point to a diminution of blood plasma volume, as the chief factor. That is, a loss of the circulating blood, and thus an insufficiency of blood return to the heart to fill that organ, and the resulting sending on when it contracts, or not only too little, but likewise a poor quality of blood.

What we have to dread is the small weak irregular rapid pulse, coupled with a fall in blood pressure and pallor, and shallow respirations. When hæmorrhage is expected, preparation by the previous administration of calcium lactate, Gr. 10, three times a day, for the previous week, with parathyroid Gr. one tenth daily, and perhaps exposure to violet rays may render the hæmorrhage less severe, especially if ox or horse serum be injected before the operation. Shock is, of course favoured by surgical tearing and traction on important organs, thus importance, where possible of velvet surgical manipulation. Blood transfusion, with a suitable donor is of great value. Subcutaneous saline with glucose injections, started early in the operation are justly of repute, subject to their absorbtion. This means put it in slowly. It is useless to have a tightly stretched area, distended with a cooling saline, that is not entering into the circulation. It is a valuable

prophylactic as Sir Arbuthnot Lane, Mr. Paterson and others have shown.

Saline injections should enter the body at a temperature of 105°F. With an ordinary thermos apparatus this can be easily ensured; with the rubber bag outfit, there is so much cooling in transit that the temperature must be quite 10 to 15 degrees higher in the bag. Care here, however, is required to avoid error in the other direction. I have known damage to have been done to the rectum by too hot a rectal saline. The immediate treatment comes to what has already been given under the previous section, plus the introduction of saline glucose fluid subcutaneously, intraperitoneally, intravenously, or rectally.

The entry of air into a vein produces immediate signs of circulatory failure and is characterised by a most sinister sound as the air rushes in. The anæsthetist must not favour this catastrophe by allowing venous engorgement through cyanosis ar faulty position. This is markedly so in cases of thyroid operation.

The syncope due to a detached thrombus, especially if in the heart, is generally fatal.

The treatment for heart failure, consequent on respiratory complications, has been dealt with under the latter heading.

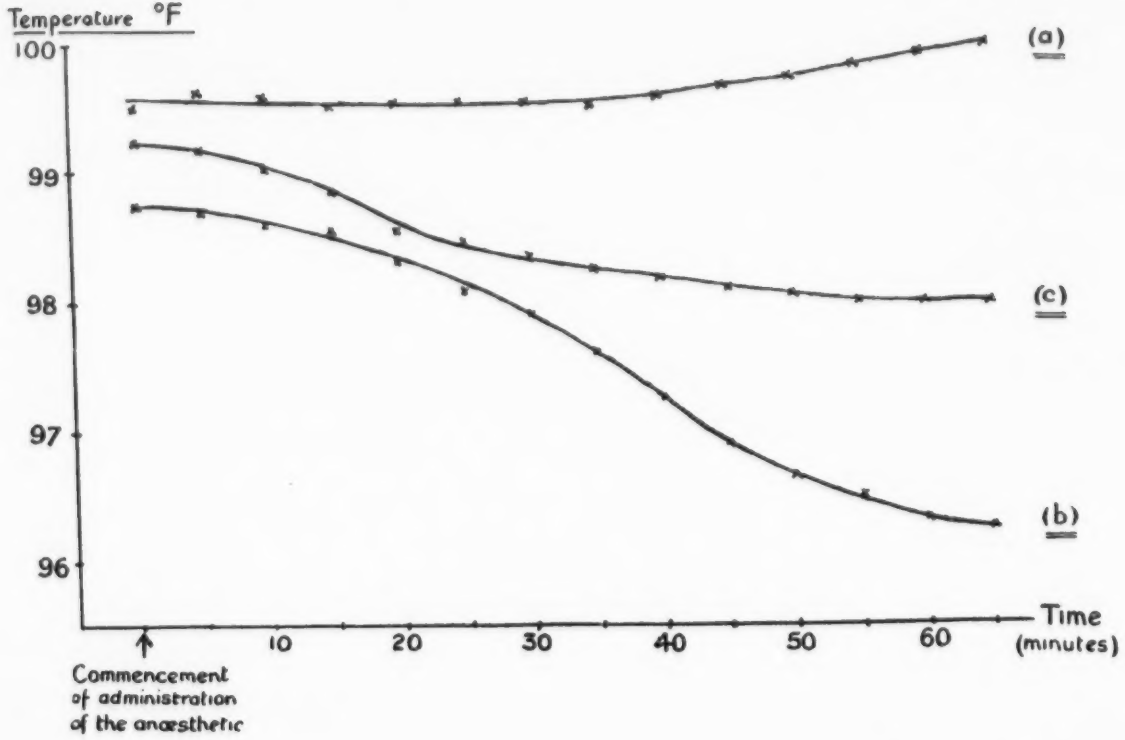
In our subject of consideration to-day, I think we must include, what is more common, than immediate or on the table emergencies, namely remote emergencies. At one time, there was but one idea of an anæsthetic death, a passing away on the operating table. More often than not it was erroneous; equally incorrect as it is on many occasions, to attribute a subsequent operation fatality, to something other than the anæsthetic. The more I work at my speciality, the more does it strike me, that an anæsthetic is not merely an interim between two periods of consciousness. It must be regarded in a more serious light. It is a serious physiological or pathological alteration in cells, and a metabolic disturbance involving serious possibilities affecting the life and future health of the patient.

For this reason, I would, in selecting the anæsthetic, urge, where possible, the least injurious. Nitrous Oxide and

Oxygen, or perhaps ethylene or acetylene with oxygen. With a mutual understanding between the surgeon and the anæsthetist, harmonious co-operation, including on the operator's part, the velvet hand method of carrying out his work, most cases, whatever their condition, may be given the benefit of operative treatment, without emergencies. This is aided if a spinal or splanchnic injection of stovaine or novocaine be also given, and perhaps nerve blocking in addition. But it is essential that the handling or crushing of nerves, intestines, traction on gut, gall bladder, mesentery or uterus, roughness with retractors, massage of peritoneum, squeezing of ovaries is reduced to a minimum. When manipulations involving such causes of shock are essential, then bubbling over or through ether or paraldehyde can be used for a few seconds, being discontinued when the exigencies of the case permits. The ether must be employed sparingly, in like manner to what a cunning cook uses garlic. Experience will soon teach the amount of bubbling over or through, that will produce for the time needed the essential relaxation. Naturally the less ether or paraaldehyde used, the better for the patient. I know it is easy to diverge into a discussion on the respective merits of chloroform and ether. Without doing this, or being a hopeless incurable advocate of the former, I venture, with all respect, to assert that though chloroform toddles between the walls of prejudice, in suitable cases, it is still a girder in the life structure of an anæsthetist's existence. This controversity bristles with diversities of opinion, and as some probably rightly advance, accidents with chloroform may occur as suddenly as an administrator may step on a piece of orange peel. He who sits with his back to possibilites may stare into the patient's coffin. Yet every door has it's key, and the raft of the observant always gets over, still there is need in chloroform especially, for observation. In our calling, there are "three graces," evaluation, preparation, and observation. They are all great but the greatest of all like charity is observation. It prevents *emergencies*. Our motto might be, "trifles make up perfection, but perfection is no trifle". We have struggled through many difficult chapters to-night together, and I must thank

you all for your attention and patience. I honestly believe that if we bear in mind the three anæsthetic graces, we will, like experienced travellers, learn to avoid quagmires and will not have a hard row to hoe in our work. Though we may play with fire, we will have the fire engines ready and being ever on guard will not require them. So much has appeared in the medical and lay press on the subject that I felt reluctant to comply with the flattering request for a paper on this topic. My only excuse for presenting various aspects as viewed through different windows must be in my conviction which I trust you all now share with me that "Emergencies" should not occur. If I have achieved that end, I will feel, that I have neither journeyed in vain, nor bored you for such a long time for nothing, though realising, as we all must, the vastness of the subject, and the difficulties in not leaving out important items in the short space of time at our disposal. I must plead for your indulgence if I have not adequately dealt with many of phases in the dots and dashes pictures I have attempted to-night to place on the convas.

Allow me, gentlemen, once more to express my thanks for your presence and attention.


Temperature °F
100
99
98
97
96
(a)
(c)
(b)
10
20
30
40
50
60
Time
(minutes)
Commencement
of administration
of the anæsthetic

A PRELIMINARY NOTE ON TEMPERATURE VARIATIONS DURING GENERAL ANÆSTHESIA.

By K. H. Watkins, B.Sc., (Manchester), and S. R. Wilson, M.Sc., M.B., Ch.B. (Manchester), B.S. (London,) F.R.C.S. (Edinburgh).,

Lecturer in Anæsthetics, University of Manchester.

WITH the use of the mercury thermometer numerous observations have been made on the change in body temperature which results from the administration of a general anæsthetic. More recently the introduction of continuously recording thermometers has rendered practicable a more accurate study of administration itself.

Only a brief description of the apparatus employed in this investigation is necessary, a full account having been published by Sims Woodhead and Varrier Jones who introduced it into clinical practice. The instrument is a platinum electrical resistance thermometer, in combination with a quasi-continuous thread recorder. The platinum wire coil is encased in a silver tube, suitable for introduction into the rectum. The wiring of the instrument has been slightly altered from that described by Sims Woodhead and Varrier Jones; this alteration has, on the advice of the Cambridge Instrument Co., been retained. The recording part of the instrument consists of a recording drum and drop bar; the latter is released every half minute or minute, and causes the galvanometer pointer to strike the drum, marking a point by means of an interposed inked thread. The procedure adopted in this investigation was to compare the instrument with a standard mercury thermometer both before and after each record, except when two records were taken on the same morning in which case the comparison was omitted between

the records. For the purpose of making the comparison the standard mercury thermometer and the electrical thermometer were placed together in warm water in a thermos flask. The two comparisons did not vary, with few exceptions, more than one-tenth of a degree Fahrenheit on any one day.

In all the experiments the anæsthetic employed was ether; the general procedure included a preliminary injection of atropine sulphate (gr. 1/60), induction by open ether with the addition of some ethyl chloride, and maintenance of anæsthesia by ether vapour. All the patients were more than twenty-five years of age. In most instances the operative measures were being directed to the relief of some chronic condition. Twenty of the operations were abdominal, and two were radical amputations of breast; the remaining five varied in nature. All the cases were investigated between the hours of 10 a.m. and 1 p.m., so that diurnal variations do not enter into the consideration.

In the majority of records obtained, a fall of temperature starting six or seven minutes after the commencement of the administration of the anæsthetic was observed. Usually the rate of fall of temperature was much greater during the first twenty-five to thirty-five minutes, than subsequenty. It is, therefore, possible to describe two phases of temperature variation :—

(a) The first phase, or phase of rapid fall of temperature, starting often six or seven minutes after the commencement of the administration, and lasting on the average for twenty-five to thiryt-five minutes.

(b) The second phase, or phase of small variation of temperature, beginning at the end of the first phase, and continuing to the end of the operation (when all the records finish).

In the results outlined below, some of the cases were not expected to show the changes described; the reason being that it was not always possible to start the record sufficiently early, or the patient was not in the operating theatre sufficiently long.

The temperature started to fall, at times varying from five to eight minutes after the commencement of the administration

(eight out of thirteen cases); a longer time than eight minutes was associated with considerable struggling during the induction (two out of three cases). In seven out of thirteen cases the separation of the two phases was sharply demarcated: in three the separation was indefinite, and in the remaining three no separation into the two phases was observed. A distinct point of separation usually occurred in twenty-five to forty minutes after the commencement of the administration (five out of seven cases).

There was always a fall of temperature during the first phase, with one exception in which the temperature did not change. In the second phase it usually showed a slight fall, or even a slight rise; rarely it showed a marked fall, the cause of which is suggested later. The amount of the temperature change has been worked out for two periods:—

(*a*) period 'I' the thirty minutes succeeding the onset of fall of temperature.

(b) period '2', the fifteen minutes lasting from forty-five to sixty minutes after the commencement of the administration.

The following figures do not include cases of acute illness or pyrexia:—

Rate of change of temperature	*Number of cases*	
	Period 'I'	*Period* '2'
0.0 to +0.3 degrees Fahrenheit per hour.	0 cases	3 cases
0.0 to −1.0 " " "	2 "	5 "
−1.0 to −2.0 " " "	5 "	2 "
−2.0 to −3.0 " " "	5 "	2 "

The average rate of change of temperature for period 'I' was a fall of 1.8 degrees Fahrenheit per hour, as compared with an average rate of fall of 0.8 in period "2." In only one out of nine cases was the fall of temperature greater in period "2" than in period "I."

The greatest actual fall of temperature recorded was one of three degrees Fahrenheit. Excluding the cases of acute illness or pyrexia, there was only one instance of a patient leaving the operating theatre with a temperature greater than that with which he entered; in this case the final temperature

was about one-fifth of a degree Fahrenheit greater than the initial temperature. It is remarkable to note the relatively small fall of temperature which occurred even in severe and long operations; for example, in the two cases of radical amputation of the breast the fall of temperature was approximately one degree Fahrenheit in each case.

It is not possible with the relatively small number of cases yet investigated to make any definite statement on the relationship between the temperature change in the patient and the temperature of the theatre. There appeared to be a tendency to higher losses in period "1" with lower theatre temperature. In period "2" the greater losses occurred, from the evidence at our disposal, at a theatre temperature of less than seventy degrees Fahrenheit; above this temperature the changes were remarkably slight.

Three patients showed slight pyrexia (100 to 101 degrees Fahrenheit—rectal) and in two of these cases the temperature showed a steady rise in the later stages; the third case did not show this rise, but also differed from the others in not having shown any pyrexia in the preceeding twenty-four hours. A similar rise of temperature was only seen in one other case, an acute intestinal obstruction. These three cases each showed in the later stages a rise of temperature at the rate of 0.8 to 1.0 degrees Fahrenheit per hour.

The temperature variation was found to be closely related to the depth of anæsthesia; thus the temperature fell more rapidly with a light degree of anæsthesia, less rapidly with a deep. On six occasions in which the anæsthesia was deepened the fall of temperature diminished in rate; in one instance the rate of fall increased, and in one other the interpretation was doubtful. On eighteen occasions the patient was allowed to show signs of lightness of anæsthesia, or else the anæsthetic was withdrawn at a sufficiently early moment to show a change before the end of the record. Of these, twelve were associated with or followed by an increased rate of temperature fall, one with an increased rate of temperature rise; the remaining five did not show any change. Since the rate of fall of temperature begins to increase with the cessation of the ether administration the temperature may be expected

to fall after the patient leaves the operating theatre; this is in agreement with the statement by Pembrey and Shipway[2] that the lowest temperature is often recorded after the operation. The two cases which showed the highest rate of fall of temperature during period "2" were cases in which the lightness of anæsthesia was a marked feature.

In two cases the administration of ether was carried through without a preliminary injection of atropine. In both cases perspiration was profuse, but in neither was the fall of temperature excessive.

A comparison of five male and five female cases showed a somewhat greater actual fall, and also a greater rate of fall in the female cases. This is markedly at variance with the statement that under ether anæsthesia the decrease of temperature in males is more than double that in females.[3]

In nine instances the records both started sufficiently early to establish definitely the initial temperature of the patient, and were of a duration of at least sixty-five minutes. From these cases the accompanying curves have been worked out:

(a) the case of acute intestinal obstruction.

(b) the average of two cases in which the anæsthesia was very light, as indicated by phonation and straining.

(c) the average of the remaining six cases.

Summary.

1. There are usually two phases in the temperature change in a patient under ether anæsthesia, the rate of fall of temperature being greater during the first phase.

2. The temperature usually begins to fall in five to eight minutes after commencing the administration of ether.

3. The rate of fall of temperature increases with a light anæsthesia, decreases with a deep anæsthesia.

4. Pyrexial patients, or patients suffering from an acute condition show a steady rise of temperature in the later stages.

This investigation has been carried out at the Manchester Royal Infirmary. We wish to thank Mr. A. H. Burgess for putting his operating theatre at our disposal, and Professor B. A. McSwiney for his help, and we are greatly indebted to the Royal Society for the use of their instrument.

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ANÆSTHETIC FATALITY.

By G. F. Rawdon Smith, M.B., B.S., M.D.,

Hon. Anæsthetist, Liverpool Royal Infirmary, etc.

THE following case of sudden death under an anæsthetic possesses certain points of interest, which make it worthy of publication.

The patient was a woman of fifty, who, until November 22nd, 1926, had never had a day's illness in her life; on that day she was taken ill with severe abdominal pain, which was treated by her husband with hot flannels, etc. Early on the morning of the 26th, Dr. Percy Shepherd was called in and, recognizing that it was a case of acute appendicitis, he sent her into the Liverpool Royal Infirmary at once.

On admission, her temperature was 98.4° and her pulse-rate 104, a mass could be felt in the right iliac fossa and there was a certain amount of tenderness in the appendix region.

It was decided to operate on the afternoon of the 26th, and during the intervening hours her temperature did not rise and her pulse-rate came down to 90.

An hour before operation 1/6 gr. of morphine and 1/100 gr. of atropine were given hypodermically.

The anæsthetic used was a sequence of chloroform-ether, about one drachm of the former being employed. As she showed considerably more excitement in the second stage than is usual with women, ether by the "open" method was substituted rather earlier than the writer generally makes the change, she took this well and settled down quickly. Just as she was to be moved into the theatre, without any warning she suddenly stopped breathing and the pulse ceased simultaneously, the colour being the ashen pallor characteristic of circulatory failure. Artificial respiration was immediately carried out and three successive doses of ½ c.c. of adrenalin (1 in 1,000) were injected into the ventricle, the only result

being that she took a few sighing respirations, the heart giving no response.

Mr. Hugh Reid then opened the abdomen and massaged the heart through the diaphragm; the heart was noticed to be in a state of ventricular fibrillation, but no proper contraction took place and the only effect of a further injection of adrenalin was another sighing respiration.

A post-mortem examination was conducted by Dr. Howel Evans, the assistant pathologist to the hospital. The appendix was found to be gangrenous and to have perforated into a localized abscess, containing about an ounce of pus; the heart weighed 11 ounces and was extremely fatty and the muscle soft, but there was no valvular disease; the rest of the organs were engorged with blood but otherwise healthy, in other words the typical picture of shock; the thymus weighed 5gms. but there was no generalized glandular enlargement. On section, the thymus proved to contain 10 per cent. glandular tissue and 90 per cent. fat.

The conclusion come to was that the patient was in a state of profound toxæmia from the appendix condition, to which there had been comparatively little reaction, as shown by the normal temperature. This toxæmia had affected the hitherto healthy heart muscle and the last straw had been the severe second stage of anæsthesia.

The points of interest to which I should like to call attention are the sighing respirations called forth by the adrenalin and the ventricular fibrillation, to which notice has been drawn by Goodman Levy in animals, but which, so far as I am aware, has not been noted in the human subject.

I should also be grateful for opinions as to whether adrenalin is a safe drug to inject where chloroform has been used, as I am not clear in this case as to which was responsible for the fibrillation, the toxæmia, the chloroform or the adrenalin.

REGIONAL AND SPINAL ANÆSTHESIA

BRACHIAL PLEXUS BLOCK: ITS CLINICAL APPLICATION.

By EDWARD M. LIVINGSTON, New York City, and
HIPPOLYTE WERTHEIM, New York City.

Read before joint meeting, American Society of Regional Anæsthesia; Canadian Society of Anæsthetists; Eastern Society of Anæsthetists, Montreal, Canada, October 27, 1926.

IN this country, blocking the brachial plexus has not become an established procedure, nor has this method of anæsthesia received wide attention. The Cumulative Index fails to list a single article of American origin, describing the use of brachial plexus anæsthesia for operations upon the upper extremity.

HISTORICAL REVIEW.

Blocking the brachial plexus was first described by Kulenkampff in 1911. This author reported twenty-five cases with complete anæsthesia in fifteen, and a partial anæsthesia, —which was sufficient for the desired operation,—in five others, but failure with the remaining five. In the same year, Hirschel published a report of six[3] additional operations performed by means of brachial injections.

It has been pointed out that every new surgical method, before becoming firmly established, must pass through three stages; a period of optimism, a period of pessimism, and a period of adjustment. The history of brachial plexus anæsthesia has been no exception to this rule. For, following these initial reports, there appeared in the literature accounts of many complications and untoward effects, following its use. Among these undesirable aspects,—some of them merely theoretical, others actually observed,—were the following: the deposit of the solution within blood vessels; injury to the

pleura or lung; paralysis of the phrenic nerve; toxic manifestations, and injury to the cords of the plexus. In addition to these complications, failure to secure surgical anæsthesia was reported in a considerable percentage of cases.

The period between 1911 and 1915 was an experimental era for brachial plexus block. Four routes of approach to the nerves were attempted. The plexus was injected from the axilla, from below the clavicle, from above the clavicle, and the individual nerves were attacked from the dorsum of the neck. The needles, the syringes, the type of drug, and the percentage of concentration, were also varied. During this period, injury to every anatomical structure in proximity to the plexus was put on record, and this inevitably cast disfavour upon the method.

However, foreign literature soon gave evidences of the passing of this period of pessimism, and the onset of a period of adjustment. The supraclavicular route of Kulemkampff became the accepted path of approach, technique became better standardized, and larger series of cases were reported. Chart 1 tabulates 1,000 such brachial plexus injections from foreign sources, giving the name of the author, his number of cases, the percentage of complete, and of partial anæsthesias, and a list of the complications observed. This review shows that the most serious complications from these 1,000 injections was a partial paralysis of the forearm, which disappeared without treatment after an interval of six months. No death occurred. The untoward results were transient. Complications occurred with less than 3 per cent. of patients. Complete surgical anæsthesia was obtained from over 80 per cent. of injections. Excluding the original report of Kulemkampff absolute failures did not exceed 7 per cent. of cases in any report, while an average of all reports was 2.4 per cent. failure.

Advantages of the Method.

The review of this literature reveals, in addition, the advantages of this form of anæsthesia. Certain objects are attained through brachial plexus block, which cannot be achieved by other methods.

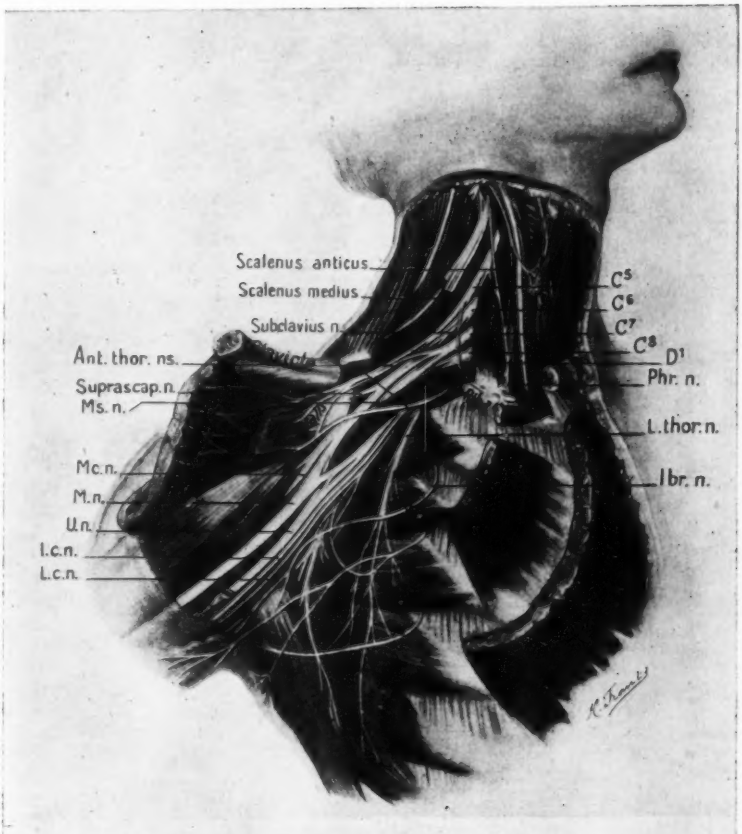

Fig. 150.—The brachial plexus (after Hirschfeld and Leveillé): *Ms.n.*, Musculospiral nerve; *Mc.n.*, musculocutaneous nerve; *M.n.*, median nerve; *U.n.*, ulnar nerve; *l.c.n.*, internal cutaneous nerve; *L.c.n.*, lesser cutaneous nerve; *Phr.n.*, phrenic nerve; *L.thor.n.*, long thoracic nerve; *Ibr.n.*, intercostobrachialis (intercostohumeral) nerve.

Plate I.—Anatomy of the Brachial Plexus. From "Regional Anæsthesia," by Gaston Labat. By permission of Dr. Labat.

First, the anæsthesia is limited to that restricted portion of the body upon which it is proposed to operate, leaving intact the vital centres.

Second. Such a block results in a physiological section of the nerves supplying the upper extremity. Painful impulses from the periphery are no longer transmitted to the brain. Shock is minimized or prevented. In traumatic cases the importance of this consideration constitutes definite indication for regional anæsthesia.

Third. To perceive the consciousness of the patient is, at times, another objective of high clinical value. This is particularly true when the operation is for the repair of lacerated tendons of the wrist, where the co-operative movement of each individual muscle renders identification of the structural units certain. Again, the conscious patient may have immediate relief while awaiting the preparation of operative facilities. This relief of pain can be carried on for hours, since repeated injections have proven to be innocuous. Also, after reduction of fractures, the patient may immediately go to the X-ray room for a follow-up plate, and a secondary reduction is both possible and painless if further correction is necessary.

Fourth. The trained surgeon can work single handed, if necessity requires, or, if a regional expert makes the injection, he is free to assist the surgeon in the operative procedure.

The advantages of brachial plexus block over local injections at or below the elbow are that the site of injection is away from lymphatic channels, diminishing the danger of passing the needle through infected tissue; the tissues are not distorted nor devitalized through the deposit of the solution at the operative site; that the muscles of the forearm, which have their attachment and innervation from above the elbow are thus relaxed; while the brachial block, with its single, shallow injection, is more simple than any other regional method upon the upper extremity.

Report of Cases.

The purpose of this article is to report results from the use of brachial plexus anæsthesia in routine hospital and

clinic practice. This work was performed in the Third Surgical Division of Bellevue Hospital (service of Dr. George David Stewart), at the Polyclinic Hospital (service of Dr. Herbert Chase), and at the Central Neurological Hospital. Several injections of this series were made by members of the house staffs, in many instances doing their first work with regional anæsthesia, and in all cases, making their first brachial plexus injections.

This report is a study of the results obtained from the administration of this form of anæsthesia to one hundred and five patients. Thirty-five cases were from the clinics and the remaining seventy were from the hospital services. Chart 2 specifies the operations performed.

Details of technique will be omitted from this clinical study. These may be found in any text dealing with regional anæsthesia. The basic routines employed were as follows:—Injections were made by the supraclavicular route of Kulenkampff. With few exceptions, a single puncture was made and the solution deposited immediately beneath the deep cervical fascia. No attempts were made to obtain paraesthesias, contact with the nerve trunks being rigidly avoided. The solution rather than the needle found the cords of the plexus. Thirty c.c. of the 2 per cent. solution was employed. In some instances this consisted of stock solution of novocaine, in others it was freshly prepared from powdered novocaine or neocaine. Patients from the outpatient departments received no preliminary medication and immediately upon completion of the operative procedure they were allowed to leave the clinic. Hospital patients were given hypodermic injections of $\frac{1}{8}$gr. of morphine one half hour before operation, and in some cases 1/150 gr. of acopalamin was added. These patients were all kept in the recumbent posture for two hours after the injection of the plexus. In certain instances an additional $\frac{1}{8}$ gr. of morphine was given shortly before the brachial block was induced.

Results.

The results are summarized in Chart 1., Clinic series: Surgical anæsthesia was obtained in 21 of the 35 patients

(60 per cent.). The anæsthesia was sufficient for the completion of the operation, but not entirely satisfactory, in 12 additional cases (35 per cent.). Two cases were complete failures (5 per cent.).

Hospital series: Surgical anæsthesia was obtained in 61 of the 70 cases (87 per cent.). The anæsthesia was adequate, but not entirely satisfactory in eight additional cases (11.5 per cent.). In one case inhalation narcosis was resorted to, and the injection considered a complete failure (1.5 per cent.).

The operations were completed without additional means of anæsthesia in 102 of the 105 cases.

Difficulties Encountered.

The chief difficulty encountered was the failure to uniformly obtain complete anæsthesia. In the strict sense of the term, complete anæsthesia is never obtained by any nerve blocking method. Touch sensations always remain, thus the patient is conscious of manipulations at the operative field, and these alone are sufficient, with many apprehensive patients, to invite failure. Even complete surgical anæsthesia leaves the patient with a residuum of sensations from the part. Furthermore, in every large series of cases there will be some in which this complete surgical anæsthesia is not obtained. The thickness of the firm, closely packed cords, and the loose areolar tissue in which they are embedded, make it difficult for the anæsthetic solution to penetrate the nerves perfectly. So great is the number and so wide the distribution of the branches of this plexus that the injection of the individual units is not attempted, and brachial plexus block is in reality simply a mass infiltration of the region. The theoretical difficulties, therefore, in attaining perfect results are very great, and most authors have reported a considerable percentage of cases with but partial anæsthesia,—cases in which the operation could be performed, but with pain sensations not entirely eliminated. These authors also agree, that there will be occasionally a complete failure. In a certain instance this might be due to a nerve anomaly, to an error in the preparation of the solution, to an unusual individual resistance to the drug, or to the accidental injection of the fluid

within a vessel, resulting in a loss of concentration at the desired site. Be the causes what they may, an occasional failure and a variable percentage of incomplete results seem inevitable, while touch and pressure sensations most certainly remain intact.

For these reasons the psychic preparation of the patient, and the use of adequate preliminary doses of narcotics are of unusual importance when employing brachial plexus anæsthesia. This fact is illustrated by the discrepancy between the end results with hospital and with clinic patients. We no longer attempt this method of anæsthesia, unless it is possible to give the patient an adequate dose of some synergistic drug, such as morphine or scopalmine.

Toxic Symptoms.

Tonic symptoms consisting of weakness in the extremities and mild mental inco-ordination were observed in one clinic patient. Flushing, tremor, and cardiac palpitation were observed more frequently,—occurring in 30 per cent. of patients injected in the sitting posture, and in five patients of the hospital series (7 per cent.). In all instances these symptoms were transient, not exceeding the period on anæsthesia,— and in most instances, momentary. No symptoms of a sufficiently serious nature to contraindicate the use of the method were observed. Nevertheless, we do not now attempt brachial plexus anæsthesia, unless arrangements are adequate for observing the patient in a recumbent posture until all danger from toxic manifestations has passed.

To sum up, the abovementioned untoward effects do not seem to contraindicate the use of the method.

Comparison with Ether Narcosis.

All methods of anæsthesia for the accomplishment of these major operations upon the upper extremity have their disagreeable aspects. The by-effects of brachial plexus block must be compared with those of other forms of anæsthesia for the accomplishment of the same ends, and their importance must be considered as relative. New methods are always on trial. The slightest disagreeable by-effect is often held to be

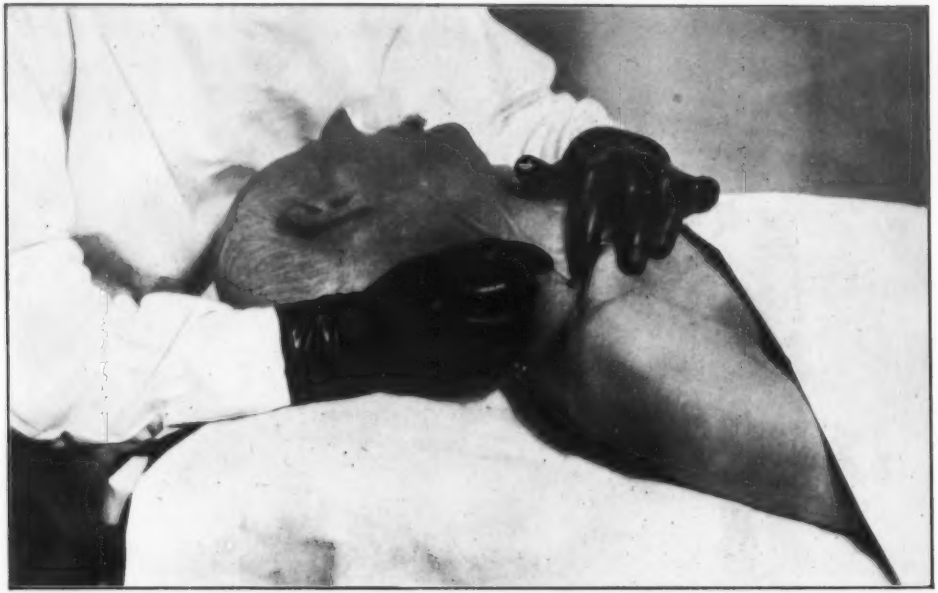

Plate II. METHOD OF PASSING NEEDLE INTO PLEXUS.

sufficient grounds upon which to condemn the entire procedure. Yet, if the untoward effects are not of a serious nature, they become matters of little concern as the method gains wider acceptance. In the case of ether narcosis,—the smothering sensation of the patient, his struggle in the excitement stage, the occasional vomiting spells, the post anæsthetic delirium, the irritable stomach, the effects upon the liver, kidney, and lung,—all are minimized. Even the occasional anæsthetic death is taken as inevitable in any considerable series of cases. It is not difficult to imagine the trepidation with which ether narcosis was at first administered. And the disagreeable features of every such administration are not to be denied. These statements are made not to be disparaging of ether narcosis, but merely to emphasize the disagreeable by-effects which exist. The merit of the method is so firmly established that these factors are all but ignored.

Upon the basis of strict comparison it cannot be said that the untoward effects from brachial plexus block are of more severity than those of inhalation narcosis. Furthermore, even in the experimental era, complications and disagreeable by-effects occurred with but a small percentage of patients, while the average patient receives his brachial plexus anæsthesia with no unfavourable symptoms.

The before going discussion of the unfavourable aspects of the subject has been intentionally alloted more space than is warranted by the frequency and severity of such occurrences. This has been given, first, to promote familiarity with all possible by-effects, second, to evaluate them, and third, to warn against too free and unguarded use of this procedure. We desire to point out certain precautionary measures which this study has impressed upon us as important considerations in securing the best results with brachial plexus anæsthesia.

Discussion of Precautionary Measures.

These measures may be briefly reviewed and summarized as follows:—

First. Synergistic drugs should be used. Although an intelligent, co-operative patient may be injected with complete success without preliminary narcotics, yet, consistently

favourable results throughout an unselected series of cases can only be obtained when the patient's alertness has been dulled before the regional block is attempted.'

Second. Contact with the nerve trunks must be avoided. The cords of the plexus cannot be touched by the needle with impunity. Shock and injury to the fibres alike are invited by the practice of seeking paraesthesias before injecting the anæsthetic solution.

Third. The operation must be delayed until the finger tips are insensitive to pain. One of the most certain causes of partial failure is to commence the operation before the the anæsthesia has had time to become complete. This interval may be as brief as five, or as long as thirty minutes. The custom of promiscuously sticking needles throughout the limb immediately after the injection has been made, for the purpose of testing the degree of anæsthesia, cannot be too strongly condemned. The patient's confidence is too often utterly destroyed by this method. An excellent rule is to keep the patient quiet for an interval of fifteen minutes and to make the first tests for anæsthesia not sooner than at the termination of this period. The regional anæsthetist should have control of the time relations of the operative schedule. Reinjection of the plexus is indicated if the finger tips are not insensitive to pain at the end of thirty minutes.

Fourth. The patient must be kept recumbent. Toxic manifestations are minimized by maintaining the patient in this posture throughout the entire period of anæsthesia.

Fifth, and last. The patient must be kept under observation until the anæsthetic effects have worn away. The induction of regional block constitutes no excuse for inadequate aftercare. The patient who has been temporarily deprived of certain faculties demands trained assistance until these faculties have been restored. Regional anæsthetists must insist that their charges receive the same thorough attention which is the routine after inhalation narcosis. This after-care is not identical in character with that following other methods, but must be equally intelligent; for example, special observation must be maintained when an insensitive forearm has been placed in a plaster cast, the extremity must

not rest upon any hard surface, must not bear the patient's weight, etc. In certain instances the injection itself has been held responsible for some effects which could be readily traced to improper after-care.

To summarize, these precautions of drug synergism, recumbency, subfacial injection, adequate delay, and trained-post anæsthetic observation are entirely in addition to the use of correct instruments and the proper technique in passing the needle. Satisfactory end results depend upon the rigid adherence to a guarded routine.

Conclusions.

1. Brachial plexus block may be employed for any operation upon the upper extremity.

2. The advantages of this form of anæsthesia are:
   (a) The anæsthesia is limited to the upper extremity, leaving intact the vital centres.
   (b) Co-operation is possible between the conscious patient and the surgeon.
   (c) The regional anæsthetist is free to assist the surgeon at the time of operation; while the surgeon-anæsthetist may work alone in emergencies.

3. The disadvantages are few:
   (a) Complications occur in but 2 per cent. of cases.
   (b) Disagreeable by-effects and complications, when present, are mild and transient; they are of no greater severity than those following other methods of anæsthesia for accomplishing the same ends.

4. Brachial plexus block cannot be successfully employed, in any series of cases, without following certain precautionary routines, and is not recommended for use in the average surgical dispensary.

5. By adhering to these precautionary routines, operations may be successfully completed without additional means of anæsthesia in 97 per cent. of cases receiving brachial plexus block.

6. These precautionary routines are:

(a) To utilize preliminary narcotics.

(b) To avoid contact with the nerve trunks.

(c) To delay operation until the full anæsthetic effect has been reached.

4. To keep the patient under observation in the recumbent posture until the anæsthetic effects have worn away.

Discussion of Dr. Livingston's Paper.

Dr. Labat: Dr. Livingston, with the co-operation of Dr. Wertheim in this paper has gone so thoroughly over the clinical aspect of brachial plexus block that I personally do not find very much to say. These gentlemen have emphasized the importance of giving narcotics before the operation; they have emphasized the importance of a perfect knowledge of the anatomy of the region, and the importance of watching the patient after operation. It is useless for me to advise that brachial plexus block be not used either in the offce or in clinics without discrimination, and unless conditions be such that the patient can be watched after the operation and kept in the recumbent position for a certain length of time, that is, until the anæsthesia has worn off. The inference has already been made by the speakers. This does not mean that brachial plexus block should never be used in clinics, but that great caution should be exercised when injecting the brachial plexus in the office or in the clinics. When it comes to hospital work, it is only a matter of choice. We are very thankful for this paper and wish to congratulate its author.

CHART I.

REPORT OF 1,000 CASES FROM LITERATURE.

Author	Date	Cases	Anæsthesia Obtained. Complete	Partial	Failures	Complications
Kulenkampff	1911	25	60% (15)	20% (5)	20% (5)	None
Hirschel	1911	3	100% (3)	None	None	None
Kulenkampff	1913	200	100% satisfactory		None	Late Paresthesias
Babitzky	1913	25	100% satisfactory		None	None Reported
Neil & Crook	1913	40	80% (32)	17.5% (7)	2.5% (1)	None
Hirschler	1913	3	Three cases of nerve injury			Longest 4 months Paresis of index finger
Hartel & Keppler	1914	200	95% (190) satisfactory		5% (10)	Paresis of diaphragm Cord. injury. Chest pain. All temporary
Scheppelman	1915	300	97% (293) satisfactory		3% (7)	One Case of pnuemothorax. No late effect
Boit	1915	110	98% (108) satisfactory		2% (2)	Marked dyspnœa on few occasions.
Flesch Thelesius	1919	21	94% (29) satisfactory		6% (2)	Paresis of arm, 1 case
Wright	1926	56	71% (40)	22% (12)	7% (4)	Paresis of arm, 2 cases Both were transient
Total		993 Cases.				
Authors Cases						
Clinic Series		35	60% (21)	35% (12)	5% (2)	Tremor,
Hospital Series		70	87% (61)	11.5% (8)	1.5% (1)	Palpitation, Dyspnœa.
			Satisfactory 97% 102 of 105 Cases.			(All Transient)

CHART 2.

Operations performed under brachial plexus block.

	Types of cases.	
1.	Infections of the hand.	22
2.	Infections of the forearm.	9
3.	Reduction of Colles fracture.	12
4.	Reduction of other fractures of the arm and forearm.	4
5.	Repair of extensor tendons at the wrist.	2
6.	Repair of flexor tendons at the wrist.	12
7.	Removal of tumours of the upper extremity.	
	(*a*) Ganglia 6	
	(*b*) Lipomata ... 5	
	(*c*) Osteomata ... 2	
	Epithelioma 1	14
8.	Operations for chronic Osteomyelitis.	9
	(*a*) Hand 8	
	(*b*) Radius 1	
9.	Repair of extensive traumata.	8
10.	Reduction of dislocations of the fingers.	4
11.	Plastic operations on the hand.	4
12.	Amputation of the forearm.	1
13.	Removal of foreign bodies from the hand.	2
14.	Median nerve suture.	2
	Total	105

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